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(54) CONTROL APPARATUS FOR LINE MARKING MACHINES

KONTROLLAPPARAT FÜR MARKIERUNGSLINIENMASCHINEN

APPAREIL POUR CONTROLER LES MACHINES A TRACER DES LIGNES SUR LES ROUTES

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Description

The present invention relates generally to apparatus for applying lines of desired configuration onto a roadway or pavement surface and more particularly to apparatus for controlling application of paint or other line marking materials to accurately repeat previously formed lines on the roadway or pavement surface.

Roadway or pavement marking lines (either centre lines or margin lines) inevitably wear out over time and the rehabilitation of these marking lines is a task that must be continually carried out by roadway maintenance organisations. The length of roadways in many countries including Australia result in a need for machinery that can accurately reform old line markings at relatively high speed so that costs can be minimised. There are in fact many difficulties involved in being able to accurately reform old making lines at high speed and some of these include difficulties with distinguishing the old line itself caused by extraneous road markings such as changes in road surface colouring, shadows, unusual colouring areas such as oil or paint splashes, and simply in some cases as a result of extreme wear of the old line. Moreover, changes in pattern configurations also cause difficulties for continuous high speed reforming of old lines.

In prior patent literature there have been disclosed many proposals for mechanising reforming of old pavement lines. Some of these are disclosed in documents US-A-3046854, US-A-3101175, US-A-3286928 and US-A-3298352, all of which would have various problems associated with being able to distinguish old line markings, to be able to accurately repeat those old line markings and more particularly, to handle changes in line patterns. In document US-A-5,054,959 there is disclosed apparatus for distinguishing old line markings on a roadway surface and in response thereto, correctly positioning paint applicator guns so that paint could be applied correctly over the old line markings. This apparatus has been used successfully but certain difficulties have arisen in relation to recognition of old line markings including pattern changes in those markings, particularly when operating at high speed.

The objective therefore of the present invention is to provide improvements in control apparatus for machinery of the type generally disclosed in US-A-5,054,959 to improve recognition of old line markings and particularly changes in pattern formats of those line markings.

Preferably it is an objective of the present invention to enable operational speeds to be improved by improved old line and line pattern recognition.

According to the present invention there is provided control apparatus for controlling application of line marking material to refurbish old line markings on a pavement surface, said control apparatus including line detection means adapted in use to transverse scan a predetermined width of said pavement surface substantially greater than a width of said old line pattern while being carried forwardly in the direction of said old line pattern, said control apparatus being characterised in that said line detection means includes means for comparing images derived from two image detector means, one mounted behind the other in the direction of travel, and including image classifier means taught through an artificial neural network to recognise line patterns and to classify transitions in the old line marking, from one pattern to another, and said apparatus, in response thereto, being effective to control line marking material applicator means to repeat accurately said old line markings including transitions in the patterns thereof, with changes of pattern being made only if said detected line marking patterns are recognized by the control apparatus as taught by said neural network.

Preferably, said control apparatus according to Claim 1 is further characterised in that a first one of said image detector means is mounted in use at a forward position whereby a first predetermined width of said pavement surface substantially greater than said old pattern width is transverse scanned, with information indicative of said old line pattern viewed by said first image detector means being retained over a first predetermined length of said pavement surface in the direction of said old line pattern, a said second one of said image detector means being mounted in use rearwardly of said first image detector means, said second image detector means being in use arranged to transverse scan a second predetermined width of said pavement surface substantially greater than the width of said old line pattern, with information indicative to said old line pattern viewed by said second image detector means being retained over a second predetermined length of said pavement surface in the direction of said old line pattern, said first image detector means further recognising transition points in said old line pattern and providing a signal indicative of said transition points to said second image detector means, said second image detector means receiving the signal indicative of transition points from said first image detector means and information from the transverse scan of said second image detector means and in response thereto, a control signal means is provided to control on/off conditions of said line marking material applicator means.

According to a preferred feature of the present invention, said first image detector means produces a lateral shift control signal indicative of lateral shift of said old line pattern as sensed, with said lateral shift control signal being adapted to control lateral movement of line marking material applicator means to correctly deposit said line marking material over lines forming said old line pattern.

Preferably the first predetermined length of scanned pavement surface is substantially greater than said second predetermined length. Conveniently said first predetermined length is about five metres in length. The first predetermined width and the second predeter-

mined widths may be equal or they may be different however, they are preferably between 400 mm and 1.2 metres, conveniently about 500 mm.

The present invention of course includes within its scope apparatus for applying line marking materials to old line pattems including control apparatus as aforesaid carried by a vehicle or the like with line marking material applicator means located rearwardly of the second line detection means.

The applicator means may be constructed as described in US-A-5,054,959 or any other suitable means could be used. The line marking material might be liquid paint including solvent based paints or water based paints, thermally or cold applied plastic strip in one part or two component mix, or any other suitable material for refurbishing old lines.

A preferred embodiment will hereinafter be described with reference to the accompanying schematic diagrams, in which:

Figure 1 represents an information flow diagram in a preferred form of control apparatus according to the present invention;

Figure 2 represents schematically operation of a survey system line detection apparatus forming part of the system illustrated in Figure 1;

Figure 3 represents schematically operation of a control system line detection apparatus forming a further part of the system illustrated in Figure 1, and

Figure 4 represents schematically operation of a mechanical system controlled by the control system for correctly actuating the line marking material applicators.

Apparatus according to the present invention may be mounted on or from a suitable vehicle such as a truck or the like capable of carrying quantities of line marking materials to refurbish lines on a desired length of roadway or pavement surface. The form of mounting may include a forwardly mounted and extending boom such as in US-A-5,054,959, but other carrying arrangements might also be used. The control apparatus conveniently includes a forwardly located survey system, a mid located control system (relative to vehicle travel/old line pattern direction), both of which are used to control a rearwardly located mechanical system for positioning and controlling application of the line marking material. Preferably, visual left and right trajectory guides are provided capable of being viewed by the driver of the vehicle so that the driver may conveniently locate the vehicle during high speed operation so that the old line pattem on the pavement surface passes within a predetermined operational width defined by the survey system.

The survey system includes a forwardly (in use) mounted CCD camera which is generally sensitive to the overall pattern of the old line markings in the pavement surface. The CCD camera of the survey system is driven from the carrying vehicles transmission (or is otherwise responsive to speed of operation of the carrying vehicle), and acquires a transverse line scan repeatedly over short discrete lengths of road surface, for example, every five mm. The optics and mounting geometry of the CCD camera of the survey system map repeated transverse line scans to approximately half a metre of road surface width. The survey system further includes an image manager that buffers and aggregates the CCD camera pixels into an array, 13 across (transverse) by 5 in the direction of vehicle travel. Each of these pixels may be about 40 mm wide (giving a transverse scan of 520 mm total) and about 1 metre long (giving a longitudinal scan of about 5 metres total).

The survey system also includes a lateral compensator which compresses a copy of the aforesaid pixel array into an array of 13 across and one (1) longitudinally. This is achieved by averaging along each column of the five by one metre pixels. The lateral compensator has conveniently been taught, through a neural network, to recognise lateral drift of the road surface image and to compensate for such lateral drift. The signal from the lateral compensator is applied both to the mechanical system and to the image classifier of the survey system to rotate left/right so that they are laterally central to their respective pixel frames. The image classifier has been taught, through a neural network, to classify transitions from one paint pattern to the next in an old pattern on the roadway surface. Transitions are defined by a state-transition diagram. Any transition detected by the survey system is signalled ahead to the control system so that it knows what kind of transition to look for.

As indicated above, the lateral compensation signal is also passed to the mechanical system which moves the line marking material applicator means left or right to position the line marking material applicator means correctly over the old line (or lines).

At any time, the current track is indicated by a setting manually input by the driver (or operator). This determines which line material applicator (paint supply gun in the case of liquid paint being applied) is in operation for a single paint line (either continuous or intermittent). If a wrong track is detected by the survey system, it issues an override signal which switches off the applicators temporarily and connects the tracking by repositioning the carriage carrying the applicators (see for example US-A-5,054,959). Furthermore, the lateral compensator can recognise paint images at the extremities of the CCD camera field of view. It will then issue an emergency shut down signal to the applicators (paint guns).

Referring now to Figure 4, the control system comprises a CCD camera, driven from the vehicle transmission (or some other vehicle speed controlled input) and acquires a transverse line scan approximately every 5 mm. The optics and mounting geometry map a transverse line scan to approximately half a metre of road width. The control system includes an image manager that buffers and aggregates the CCD pixels into an array 13 across by 10 along the direction of travel. Each pixel

in the array may be approximately 40 mm wide giving a total width in the array of 520 mm and 30 mm long giving an approximate length of the array of 300 mm. The incoming lateral compensation signal causes images in the Transition Detector to rotate left/right so that they are laterally central to their pixel frame.

The Transition Detector has been taught, through a Neural Network, to recognise the exact point at which a transition occurs between one line pattern and the next. The Transition Detector uses not only the buffered image from the CCD camera of the control system, but also the incoming pattern classification from the survey system, to determine what kind of signal to send to the line marking material applicators. The applicator signals may be:

"P" ≡ pulse ≡ on for 3m and off for 8.5 m which is the normal line/spacing configuration for intermittent road lines in Australia

"O" ≡ open
"C" ≡ close

Figure 4 illustrates schematically the control system for the mechanical system which may be constructed as in US-A-5,054,959. In the following discussion reference is made to paint guns, however, other forms of applicators could be used depending on the nature of the line marking material used. The paint gun actuators are signalled open/closed by the gun control module. It receives signals O, C or P from the control system. "P" (or pulse) results in a timed open-close sequence from the paint gun control module. The paint guns can be shut down (until manually reset by the driver/operator) with a gun shut down signal from the survey system. This is a fail-safe mechanism to avoid out of range paint application. When a track change over-ride signal is received from the survey system, the paint guns momentarily shut off to allow the gun carriage to take up its correct position. Lateral control signals cause the gun carriage to move left or right for lateral compensation of the vehicles trajectory. Both the gun control module and the carriage control module have control loops to effect proper gun actuator movement and carriage position.

Claims

1. Control apparatus for controlling application of line marking material to refurbish old line markings on a pavement surface, said control apparatus including line detection means adapted in use to transverse scan a predetermined width of said pavement surface substantially greater than a width of said old line pattern while being carried forwardly in the direction of said old line pattern,

   said control apparatus being characterised in that said line detection means includes means for comparing images derived from two image detector means, one mounted behind the other in the direction of travel, and including image classifier means taught through an artificial neural network to recognise line patterns and to classify transitions in the old line marking, from one pattern to another, and said apparatus, in response thereto, being effective to control line marking material applicator means to repeat accurately said old line markings including transitions in the patterns thereof, with changes of pattern being made only if said detected line marking patterns are recognized by the control apparatus as taught by said neural network.

2. Control apparatus according to Claim 1, further characterised in that a first one of said image detector means is mounted in use at a forward position whereby a first predetermined width of said pavement surface substantially greater than said old pattern width is transverse scanned,

   with information indicative of said old line pattern viewed by said first image detector means being retained over a first predetermined length of said pavement surface in the direction of said old line pattern,
   a said second one of said image detector means being mounted in use rearwardly of said first image detector means, said second image detector means being in use arranged to transverse scan a second predetermined width of said pavement surface substantially greater than the width of said old line pattern,
   with information indicative to said old line pattern viewed by said second image detector means being retained over a second predetermined length of said pavement surface in the direction of said old line pattern,
   said first image detector means further recognising transition points in said old line pattern and providing a signal indicative of said transition points to said second image detector means, said second image detector means receiving the signal indicative of transition points from said first image detector means and information from the transverse scan of said second image detector means and in response thereto, a control signal means is provided to control on/off conditions of said line marking material applicator means.

3. Control apparatus according to Claim 2, characterised in that said first image detector means further produces a lateral shift control signal indicative of a lateral shift of said old line pattern as sensed with said lateral shift control signal being adapted to control lateral movement of line marking material appli-

cator means to correctly deposit said line marking material over lines forming said old line pattern.

4. Control apparatus according to Claim 2 or Claim 3, wherein said first predetermined length of scanned pavement surface is substantially greater than said second predetermined length.

5. Control apparatus according to Claim 4, further characterised in that said first predetermined length is about five metres.

6. Control apparatus according to Claim 4 or Claim 5, further characterised in that said first and second predetermined widths are between 400 mm and 1200 mm.

7. Apparatus for applying line marking material to refurbish an old line pattern on a pavement surface, said apparatus including a control apparatus according to any one of the preceding claims.

Patentansprüche

1. Steuervorrichtung zum Steuern der Aufbringung von Linienmarkierungsmaterial für die Wiederherstellung von alten Linienmarkierungen auf einer Fahrbahnfläche, wobei die Steuervorrichtung eine Linienerfassungseinrichtung enthält, die bei Betrieb eine vorbestimmte Breite der Fahrbahnfläche in Querrichtung abtasten kann, die wesentlich größer ist als die Breite des alten Linienmusters, während sie in Richtung des alten Linienmusters vorwärts geführt wird,

   wobei die Steuereinrichtung dadurch gekennzeichnet ist, daß die Linienerfassungseinrichtung eine Einrichtung zum Vergleichen von Bildern enthält, die von zwei Bilderfassungseinrichtungen erhalten werden, die hintereinander in Bewegungsrichtung angebracht sind und Bildklassierungseinrichtungen enthalten, welche durch ein neuronales Netzwerk belehrt werden, um Linienmuster zu erkennen und Übergänge in der alten Linienmarkierung von einem Muster zu einem anderen zu klassieren, und daß die Vorrichtung in Abhängigkeit hiervon tätig wird, die Aufbringeinrichtung für das Linienmarkierungsmaterial zu steuern, um die alten Linienmarkierungen einschließlich der Übergänge in deren Muster genau zu wiederholen, wobei Musteränderungen nur durchgeführt werden, wenn die erfaßten Linienmarkierungsmuster von der Steuervorrichtung als durch das neuronale Netzwerk gelehrt erkannt werden.

2. Steuereinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß eine erste der Bilderfassungseinrichtungen bei Betrieb in einer Vorwärtsanordnung angebracht ist, wodurch eine erste vorbestimmte Breite der Fahrbahnfläche, die wesentlich größer ist als die Breite des alten Musters, in Querrichtung abgetastet wird,

   daß Information, die das von der ersten Bilderfassungseinrichtung betrachtete alte Linienmuster angibt, über eine erste vorbestimmte Länge der Fahrbahnfläche in Richtung des alten Linienmusters beibehalten wird,
   daß eine zweite der Bilderfassungseinrichtungen bei Betrieb von der ersten Bilderfassungseinrichtung rückwärts angebracht ist, wobei die zweite Bilderfassungseinrichtung bei Betrieb so angeordnet und eingerichtet ist, daß sie eine zweite vorbestimmte Breite der Fahrbahnfläche in Querrichtung abtastet, die wesentlich größer ist als die Breite des alten Linienmusters,
   daß Information, die das von der zweiten Bilderfassungseinrichtung betrachtete alte Linienmuster angibt, über eine zweite vorbestimmte Länge der Fahrbahnfläche in Richtung des alten Linienmusters beibehalten wird,
   und daß die erste Bilderfassungseinrichtung ferner Übergangspunkte im alten Linienmuster erkennt und ein die Übergangspunkte angebendes Signal auf die zweite Bilderfassungseinrichtung gibt, wobei die zweite Bilderfassungseinrichtung das die Übergangspunkte angebende Signal von der ersten Bilderfassungseinrichtung sowie Information von der Querabtastung der zweiten Bilderfassungseinrichtung empfängt und in Abhängigkeit davon eine Steuersignaleinrichtung den Einschalt/Ausschaltzustand der Aufbringeinrichtung für das Linienmarkierungsmaterial steuert.

3. Steuervorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die erste Bilderfassungseinrichtung ein Seitenverschiebungs-Steuersignal erzeugt, das eine Seitenverschiebung des alten Linienmusters gemäß der Abtastung anzeigt, wobei das Seitenverschiebungs-Steuersignal zur Steuerung einer seitlichen Verschiebung der Aufbringeinrichtung für das Linienmarkierungsmaterial geeignet ist, um das Linienmarkierungsmaterial genau über das alte Linienmuster bildenden Linien aufzubringen.

4. Steuervorrichtung nach Anspruch 2 oder 3, bei welcher die vorbestimmte Länge der abgetasteten Fahrbahnfläche wesentlich größer ist als die zweite vorbestimmte Länge.

5. Steuervorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die erste vorbestimmte Länge etwa 5 m beträgt.

6. Steuervorrichtung nach Anspruch 4 oder 5, dadurch gekennzeichnet, daß die erste und zweite vorbestimmte Breite zwischen 400 mm und 1200 mm liegen.

7. Vorrichtung zum Aufbringen von Linienmarkierungsmaterial zur Wiederherstellung eines alten Linienmusters auf einer Fahrbahnfläche, wobei die Vorrichtung eine Steuervorrichtung nach einem der vorangehenden Ansprüche enthält.

Revendications

1. Dispositif de commande pour contrôler l'application de matériau de marquage de ligne afin de restaurer d'anciens marquages de lignes sur une surface de chaussée, ledit dispositif de commande comprenant des moyens de détection de ligne adaptés en service pour balayer transversalement une largeur prédéterminée de ladite surface de chaussée sensiblement supérieure à une largeur dudit ancien motif de ligne tout en étant déplacés vers l'avant dans la direction dudit ancien motif de ligne,

   ledit dispositif de commande étant caractérisé en ce que lesdits moyens de détection de ligne comprennent des moyens pour comparer des images obtenues de deux moyens détecteurs d'image, l'un monté derrière l'autre dans la direction de déplacement, et comprenant des moyens de classification d'image pilotés par un réseau neuronal afin de reconnaître des motifs en ligne et de classer des transitions dans l'ancien marquage de ligne, d'un motif à l'autre, et ledit dispositif, en réaction à cela, agissant pour contrôler des moyens applicateurs de matériau de marquage de ligne afin de reproduire avec précision lesdits anciens marquages de ligne, y compris les transitions dans leurs motifs, des modifications de motif n'étant apportées que si lesdits motifs de marquage de ligne détectés sont reconnus par le dispositif de commande tel qu'il est piloté par ledit réseau neuronal.

2. Dispositif de commande selon la revendication 1, caractérisé en ce qu'un premier desdits moyens détecteurs d'image est monté en service dans une position avant, de sorte qu'une première largeur prédéterminée de ladite surface de chaussée sensiblement supérieure à la largeur dudit ancien motif est balayée transversalement,

   des informations représentatives dudit ancien motif de ligne vu par lesdits premiers moyens détecteurs d'image étant relevées sur une première longueur prédéterminée de ladite surface de chaussée dans la direction dudit ancien motif de ligne,
   ledit deuxième desdits moyens détecteurs d'image étant monté en service à l'arrière desdits premiers moyens détecteurs d'image, lesdits deuxièmes moyens détecteurs d'image étant agencés en service pour balayer transversalement une deuxième largeur prédéterminée de ladite surface de chaussée sensiblement supérieure à la largeur dudit ancien motif de ligne,
   des informations représentatives dudit ancien motif de ligne vu par lesdits deuxièmes moyens détecteurs d'image étant relevées sur une deuxième longueur prédéterminée de ladite surface de chaussée dans la direction dudit ancien motif de ligne,
   lesdits premiers moyens détecteurs d'image reconnaissant de plus des points de transition dans ledit ancien motif de ligne et délivrant un signal représentatif desdits points de transition auxdits deuxièmes moyens détecteurs d'image, lesdits deuxièmes moyens détecteurs d'image recevant le signal représentatif de points de transition depuis lesdits premiers moyens détecteurs d'image et des informations par le balayage transversal desdits deuxièmes moyens détecteurs d'image et en réaction à cela, des moyens de signal de commande sont prévus pour contrôler l'état marche/arrêt desdits moyens applicateurs de matériau de marquage de ligne.

3. Dispositif de commande selon la revendication 2, caractérisé en ce que lesdits premiers moyens détecteurs d'image produisent de plus un signal de commande de déplacement latéral représentatif d'un déplacement latéral dudit ancien motif de ligne détecté, ledit signal de contrôle de déplacement latéral étant adapté pour contrôler le mouvement latéral des moyens applicateurs de matériau de marquage de ligne afin de déposer correctement ledit matériau de marquage de ligne par-dessus des lignes formant ledit ancien motif de ligne.

4. Dispositif de commande selon la revendication 2 ou 3, dans lequel ladite première longueur prédéterminée de surface de chaussée balayée est sensiblement supérieure à ladite deuxième longueur prédéterminée.

5. Dispositif de commande selon la revendication 4, caractérisé en ce que ladite première longueur prédéterminée est d'environ cinq mètres.

6. Dispositif de commande selon la revendication 4 ou 5, caractérisé en ce que lesdites première et deuxième largeurs prédéterminées sont comprise entre 400 mm et 1200 mm.

7. Dispositif pour appliquer du matériau de marquage

de ligne afin de restaurer un ancien motif de ligne sur une surface de chaussée, ledit dispositif comprenant un dispositif de commande selon l'une quelconque des revendications précédentes.

Fig 1.

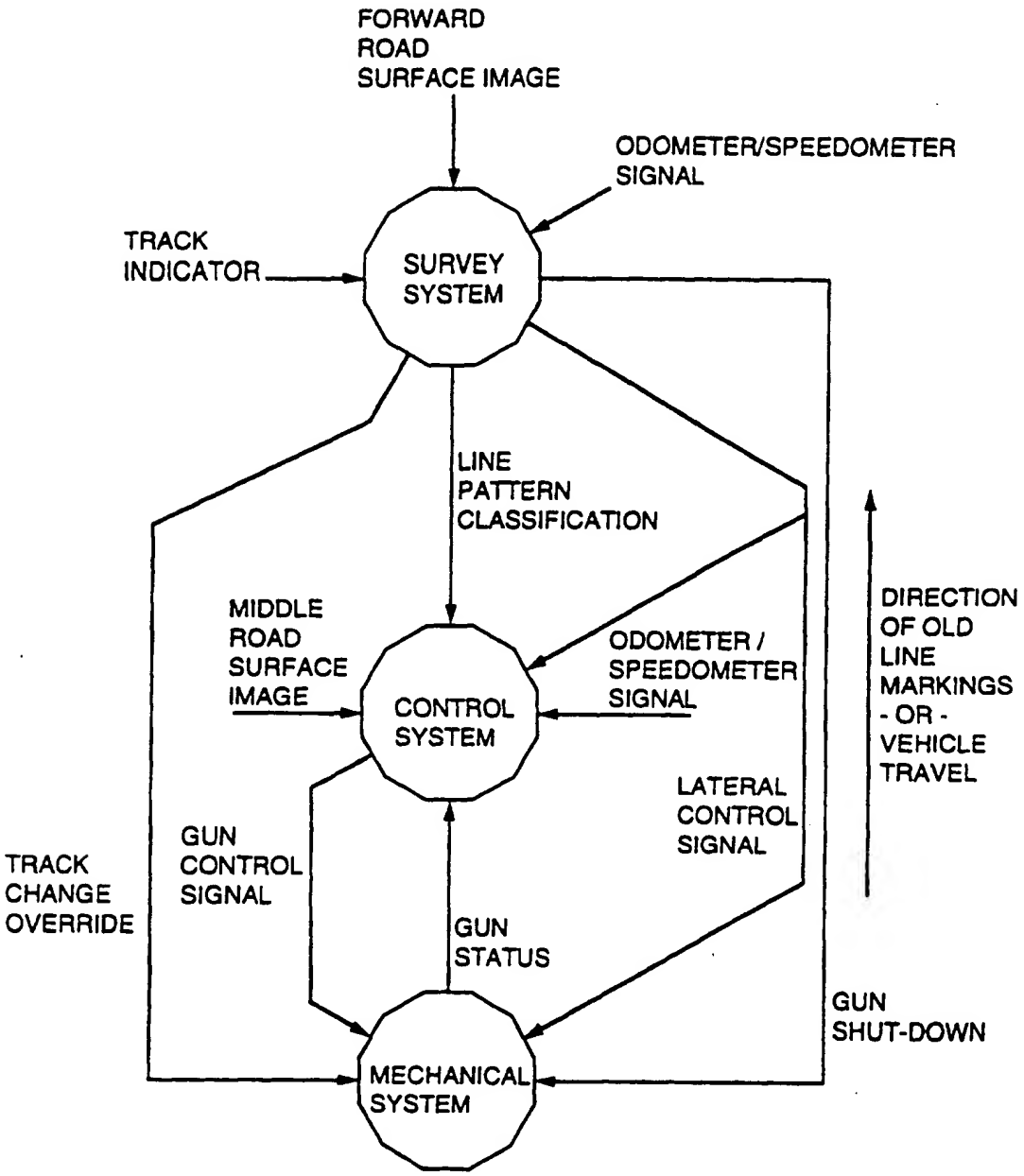
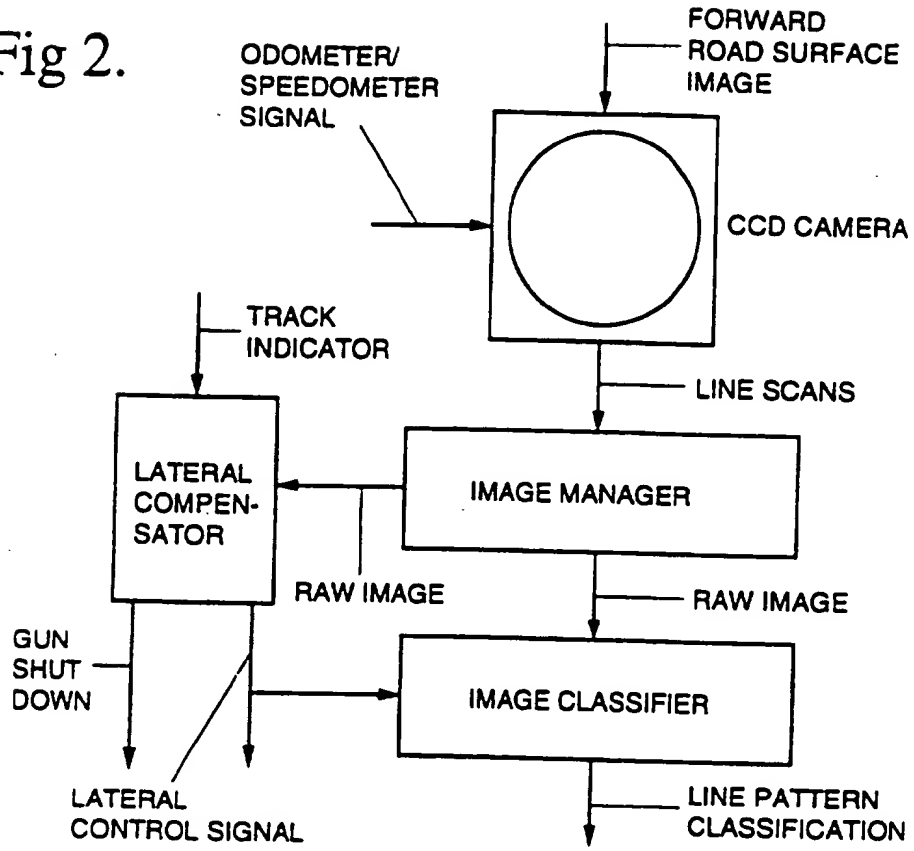

FORWARD
ROAD
SURFACE IMAGE
ODOMETER/SPEEDOMETER
SIGNAL
TRACK
INDICATOR
SURVEY
SYSTEM
LINE
PATTERN
CLASSIFICATION
DIRECTION
OF OLD
LINE
MARKINGS
- OR -
VEHICLE
TRAVEL
MIDDLE
ROAD
SURFACE
IMAGE
CONTROL
SYSTEM
ODOMETER /
SPEEDOMETER
SIGNAL
LATERAL
CONTROL
SIGNAL
GUN
CONTROL
SIGNAL
TRACK
CHANGE
OVERRIDE
GUN
STATUS
GUN
SHUT-DOWN
MECHANICAL
SYSTEM

Fig 2.


FORWARD
ROAD SURFACE
IMAGE
ODOMETER/
SPEEDOMETER
SIGNAL
CCD CAMERA
TRACK
INDICATOR
LINE SCANS
LATERAL
COMPEN-
SATOR
IMAGE MANAGER
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RAW IMAGE
GUN
SHUT
DOWN
IMAGE CLASSIFIER
LATERAL
CONTROL SIGNAL
LINE PATTERN
CLASSIFICATION

Fig 3.

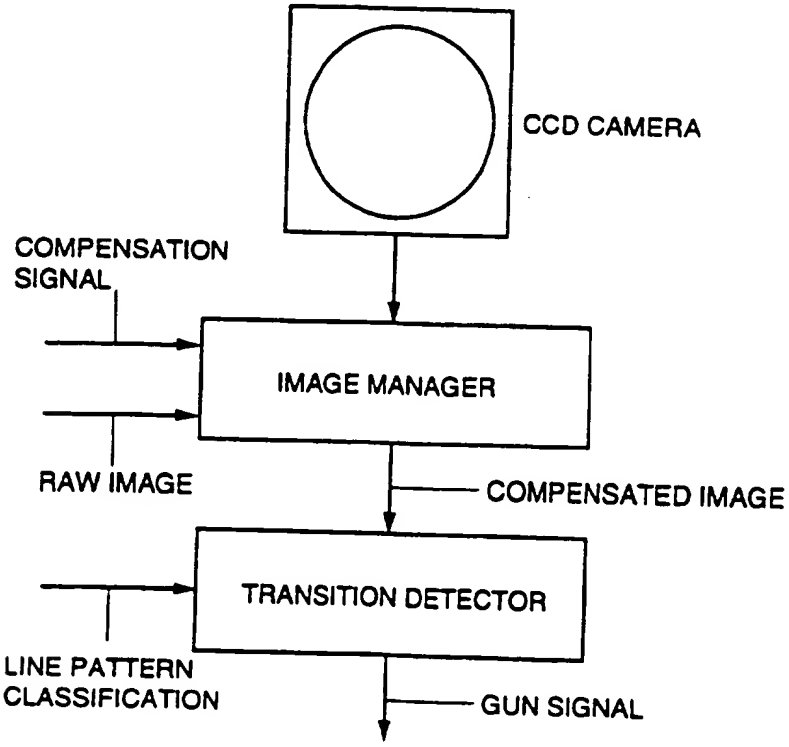
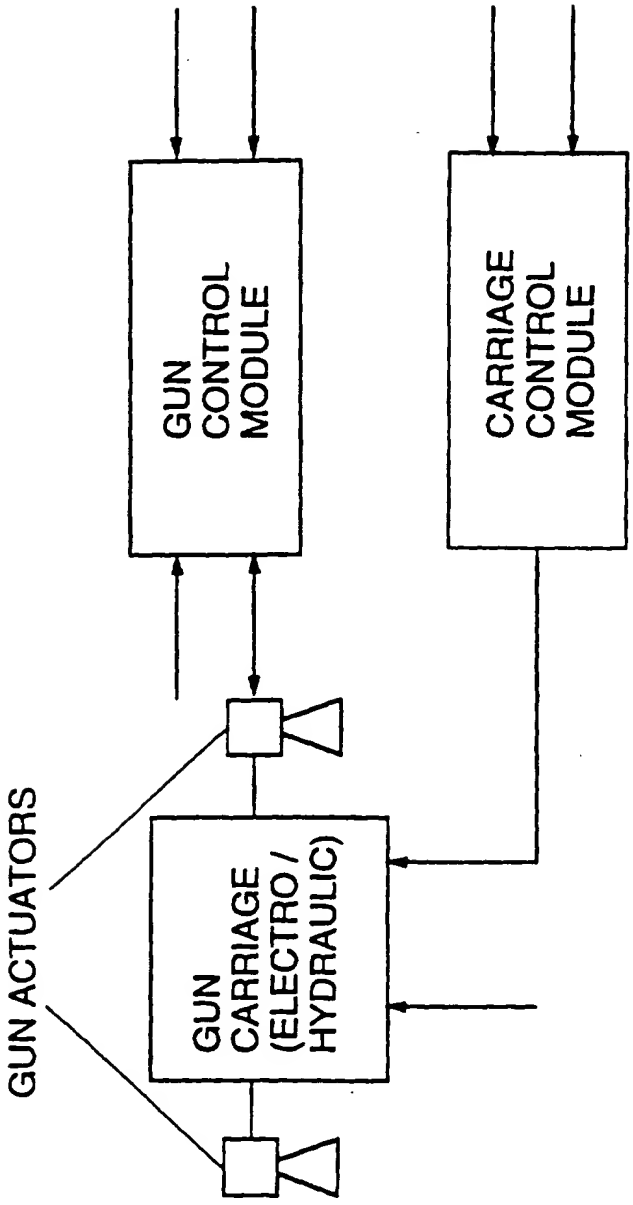

CCD CAMERA
COMPENSATION
SIGNAL
IMAGE MANAGER
RAW IMAGE
COMPENSATED IMAGE
TRANSITION DETECTOR
LINE PATTERN
CLASSIFICATION
GUN SIGNAL

Fig 4.


GUN CONTROL MODULE
CARRIAGE CONTROL MODULE
GUN ACTUATORS
GUN CARRIAGE (ELECTRO / HYDRAULIC)